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THE FIELD INVESTIGATION OF EPIDEMIC POLIOMYELITIS (WHAT THE HEALTH OFFICER CAN DO TOWARD SOLVING A NATIONAL PROBLEM).[a]

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PREVALENCE AND SERIOUSNESS.

Epidemic poliomyelitis, which has for many years been recognized at intervals in circumscribed localities as a serious problem for the guardians of the public health, has in the present year become in the United States one of our national public health problems. It has become so chiefly by reason of its enormously increased prevalence—an increase both in the total number of persons affected and in the area of epidemic prevalence.

Lovett (1),[b] in a compilation prepared for the Massachusetts state board of health, gives the number of cases of poliomyelitis reported in the literature of the world as occurring in epidemics by five-year periods from 1880 to 1909, as follows:

Five-year period.	Cases.	Epidemics.	Average number of cases.
1880–1884	23	2	11.5
1885–1889	93	7	13.0
1890–1894	151	4	38.0
1895–1899	345	23	15.0
1900–1904	349	9	39.0
1905–1909	8,054	25	322.0

After making all due allowance for the increase due to greater accuracy of diagnosis, it is still clearly evident that there has been an actual, progressive, and rapid increase in the occurrence of epidemics of this disease. And, what is of more vital importance to us, of the 8,000 cases reported from 1905 to 1909, approximately 5,000 have occurred in the United States, practically all within the three years 1907–1909. The cases in 1907 were confined quite definitely

[a] Read at the Tenth Annual Conference of Sanitary Officers of New York, Buffalo, N. Y., November 18, 1910.

[b] For references see end of article, p. 1676.

to New York City and its vicinity. Epidemics were reported in 1908 from several States, in 1909 from at least 4, and in 1910 from at least 17 States.

The Surgeon-General of the Public Health and Marine-Hospital Service is endeavoring to collect from the health officials of all the States reports of the prevalence of the disease in 1910. These reports (2), known to be fragmentary as yet, indicate approximately 2,500 cases reported from 23 States; and additional reports, unofficially received, make it quite certain that 3,000 is a minimum estimate of the cases occurring in the United States during 1910.

These figures, to be sure, are not alarming when compared with the statistics of other infectious diseases; but there are, in the prevalence of epidemic poliomyelitis, certain features which add to the seriousness of the problem. First, its rapidly progressive increase, indicating, so far as predictions are justifiable, that the situation for the ensuing year will be more serious than at present. Again, while the mortality of the disease, averaging perhaps 10 to 15 per cent, is not greater than that of other more widespread infections, the mortality in this case represents but a small part of the suffering and economic loss entailed. A very large percentage of those who escape with their lives are left with a permanent disability of greater or less degree, which often results in a lifetime of dependence on the part of the victim and of distress on the part of his family. Epidemics of other diseases come, go, and are forgotten; but epidemics of poliomyelitis leave in their wake cripples who will remain as objects of sympathy, often as objects of charity, to the next generation. Another most serious feature of epidemic poliomyelitis is the mystery which still surrounds its origin and means of dissemination, resulting in a lack of confidence in preventive measures and a magnification in the popular mind of the terrors of the disease.

PREVENTABILITY.

It is not, however, the seriousness of epidemic poliomyelitis, but its preventability, which fastens upon the health officer his responsibility in the matter; the seriousness of the disease only increases the gravity of this responsibility. So long as a disease is known to be irremediable the health officer may stand by and commiserate; if there is reason to suspect that it is preventable it is his duty to investigate; if it is known to be preventable, he must prevent.

To define the status of the health officer in regard to epidemic poliomyelitis, it will be necessary first to give a brief summary of facts bearing on its preventability.

Laboratory studies, a large and valuable part of which has been contributed by Flexner and Lewis from the Rockefeller Institute, have demonstrated that the disease is transmissible from human beings to monkeys and from monkey to monkey; animals other than the monkey have been found insusceptible, except by a few observers who report successful inoculations of rabbits (3, 4, 5).

It has been demonstrated that the specific causative organism is of minute size, being able to pass through a Berkefeld filter; that it is easily killed by heat and by comparatively weak disinfectants; that it is very resistant to cold and to drying. In the bodies of infected animals the virus (germ) of the disease has been demonstrated not

only in the spinal cord and brain, but in the nasal mucous membrane, the salivary glands, mesenteric glands, and, after subcutaneous inoculation, at the site of inoculation and in the lymph glands receiving the drainage from that area. The cerebro-spinal fluid and blood have been found infectious in the early stages of the disease. It appears, however, that the virus is present in the blood only in the early stages of infection and then in small amounts.

The most uniformly successful method of inoculating monkeys is by injection of the virus into the central nervous system, but successful inoculations have been made into the peripheral nerves, intravenously, intraperitoneally, and subcutaneously; also, which is of great importance, by introducing the virus into the stomach or intestines, by rubbing it into the scarified mucous membrane of the nose, and, as reported by one observer, by bathing the uninjured nasal mucosa with an emulsion of the virus (6).

Immunity after an attack of the disease is manifested in monkeys by insusceptibility to reinoculation. In the blood of both persons and monkeys after recovery from the disease specific antibodies have been demonstrated, capable of neutralizing in vitro certain amounts of the virus. The efforts to produce an antitoxin of therapeutic value have so far been unsuccessful, as have also the efforts to devise a safe means of protective inoculation or vaccination.

Reviewing briefly the results of laboratory experiments, it is shown that epidemic poliomyelitis is an acute infection due to a specific micro-organism. The demonstration that the secretions of the nose and mouth are infectious even in monkeys inoculated intracranially, and the successful inoculation of monkeys through the respiratory and digestive tracts, form a convincing chain of evidence that the disease is transmissible by direct contagion.

Epidemiological studies have, to some extent, confirmed the inference drawn from experimental work, that epidemic poliomyelitis is transferred from person to person by direct contact, and have further indicated the probability of conveyance of the disease by healthy persons. Widely divergent inferences have, however, been drawn from the study of epidemics in different localities.

Wickman (7) stands as the pioneer in the epidemiology of poliomyelitis, having convinced himself, by extensive field studies in Sweden, that the disease is spread by direct contact. Other observers, reporting epidemics, have emphatically stated that there was no evidence of contagion. Such divergences of opinion may be partly explained by differences in the thoroughness of investigation and in the personal equation of the observers. It must be evident, however, to anyone studying the reports that epidemics of poliomyelitis vary greatly in their degree of infectivity and in their apparent relation to contact.

Clinical studies have taught that the disease is protean in its manifestations, often diverging widely from the classical descriptions generally given in text-books. This fact is important from an epidemiological standpoint, as it raises, at the very outset, an obstacle alike to investigation and prevention, namely, the difficulty of recognizing the disease. Of extreme importance in this connection is the occurrence of abortive forms of poliomyelitis—cases in which there is no paralysis. The absolute diagnosis of such cases has, in the past, often been impossible. There is, however, reason to hope that diagnostic

methods worked out within the last year will aid greatly in their future recognition.

As regards the preventability of poliomyelitis, then, the disease is certainly due to a specific microorganism which can be quite readily destroyed by the usual methods of disinfection. It is, therefore, preventable, provided that we can locate the organism accurately and apply the germicides thoroughly. The first problem is to locate the organism in that part of its cycle where it can be most readily destroyed. Our present knowledge indicates that man is the essential host, the breeding place of the organism, and that prevention should consist in the destruction of the organism as it is excreted from the body of the patient. The efficiency of such preventive measures remains, however, to be demonstrated. While it is, therefore, the duty of every health officer for the present to put into effect the preventive measures already indicated, it is highly important that he should at the same time make diligent investigation to ascertain whatever deficiencies there may be in such methods and to point out the means of supplementing or supplanting them.

FIELD INVESTIGATIONS.

Invaluable as laboratory studies have been and will continue to be in formulating knowledge of epidemic diseases, such investigations, often of necessity carried out at a distance from the field, never have given, and perhaps never will give, a complete knowledge of the conditions governing the spread of epidemic diseases. First-hand knowledge of attendant conditions, derived from observations in the field, have always been necessary to give a practical solution to the problem of the control of any epidemic disease; and this is especially true in regard to epidemic poliomyelitis, which seems in so many respects to disregard the laws which are supposed to govern epidemics of contagious diseases.

MORBIDITY REPORTS.

It is of the utmost importance to ascertain the exact prevalence of the disease. To accomplish this it is absolutely essential that the disease be made reportable in all States. The transmissibility of epidemic poliomyelitis has already been sufficiently indicated to justify such a requirement on the ground of protection to the community; and as a means of obtaining accurate statistics the measure is absolutely essential. Laws to this effect have already been made in a number of States, and it is to be hoped that in the coming year all other States will follow their example.

So far the disease has been made reportable chiefly, if not solely, in States where its prevalence has already alarmed the people. Other States should not postpone their legislation until such circumstances make it imperative, but should at once enact laws to keep them forewarned and forearmed.

The importance of obtaining reports of all cases of anterior poliomyelitis may be illustrated by a few examples:

1. Our knowledge of its prevalence is at present derived largely from unofficial reports of epidemics. These reports embrace for the most part only outbreaks of sufficient magnitude to have attracted special attention and study, failing very often to take account of

scattered so-called sporadic cases. The result is a failure to give an accurate idea of the actual prevalence of the disease and, what is perhaps of greater importance, a failure to grasp the connection between seemingly isolated cases and epidemic foci. A case which appears absolutely isolated to the attending physician or even to the local health authorities may be seen by the state health officer, who has before him reports of all cases in the State, to have a definite relation to some epidemic focus.

2. By reports of all cases, the isolated as well as the epidemic, valuable inferences may be drawn as to the influence of many large factors, such as density of population, routes of travel, climatic conditions, drainage, the prevalence of insects, the prevalence of paralysis of animals; all of these being points concerning which the most careful intensive study of epidemic foci alone is apt to give erroneous impressions.

3. Prompt and accurate morbidity reports are obviously necessary as a preliminary to intensive study of cases. An edict making poliomyelitis reportable in Sweden laid the foundation for the epidemiological study of poliomyelitis, making possible the extensive studies of Wickman.

Reports from a large area of country can not be expected to be accurate in detail. Such reports must necessarily be obtained from hundreds of different observers, each introducing an unknown coefficient of error in his own personal bias. To reduce this error, such extensive reports should be made as simple as possible, embracing only bare facts, in reporting which the chances of error due to faulty observation, carelessness in expression, or unwarranted inferences are reduced to a minimum. Much will be lacking in these reports, much that is of importance in interpreting the laws of epidemic poliomyelitis; but they will at least have the advantage of being broad and, what is better, of being accurate.

INTENSIVE FIELD INVESTIGATIONS.

To supplement the extensive knowledge gained by collective reports, it is necessary to have other observations not less accurate, but more detailed. These observations must be made by individual intensive studies, in which thoroughness and accuracy must be the first aim, extensiveness of observation secondary. Accuracy in such studies may best be obtained by the employment of specially trained, experienced observers; uniformity by having the men engaged in such work keep in close touch with each other; extensiveness by having a large number of observers, each of them devoting as much as possible of his time to the work. In some instances the local health officer can best make these studies, especially in small localized outbreaks, having as he does the advantage of local knowledge. In most cases, however, it is better to have the studies undertaken by the State, especially studies of epidemics so large as to require more time than the local health officer can devote and studies of cases so widely scattered as to be inaccessible to one having local duties to perform. The local health officer can, however, even when he is not the principal in the study, be an invaluable ally, being already possessed of a knowledge of local conditions which a stranger in the community would have difficulty in acquiring without his aid.

Our knowledge of the epidemiology of poliomyelitis is based on the result of comparatively few field studies. Wickman has contributed a careful intensive study of over 1,000 cases occurring in Sweden in 1905–6, a study which is still unsurpassed in combined extent and thoroughness. The collective investigation committee of the New York Neurological Society (9) made a careful study of the epidemic of about 2,500 cases occurring in and around New York in 1907. The Massachusetts state board of health has been actively engaged since 1907 in the study of the disease in that State. Their report for 1909 (1), giving the distribution of cases in the State for three years and the results of the intensive study of 150 cases, is as valuable a contribution as has ever been made to the subject and serves admirably to illustrate the advantages of combining intensive personal studies with collective reports. Minnesota has made some excellent studies on similar lines (15), the results of which have not yet been published in full. Some interesting contributions have also been made from Nebraska (10, 11), and scattered reports of smaller outbreaks from various places. During the present year the collective and intensive studies have been continued in Massachusetts and Minnesota and similar studies undertaken in Iowa. A number of other States, including Virginia, Pennsylvania, Connecticut, and Kansas, and doubtless still others, have undertaken at least collective studies of the disease, while in the District of Columbia a collective study has been undertaken by an organization of the medical profession.

The information gathered from the studies in 1910 will be very valuable, but still not sufficient. Reports are wanted from every State to give a clear idea of the situation and how to control it.

METHODS OF INTENSIVE FIELD STUDY.

To take up now in detail the objects, methods, and difficulties of an intensive study of epidemic poliomyelitis:

COLLECTION OF CASES.

The official morbidity reports must first be verified as to accuracy of date and diagnosis. Almost invariably, too, these reports will have to be supplemented by the addition of abortive and suspected cases. It is not even to be expected as yet that official reports will include all the abortive cases of poliomyelitis occurring in a community, although the wide discussion of the subject now taking place, calling attention to the existence of such cases, will undoubtedly result soon in their more general recognition.

Wickman (7), in reporting his exhaustive studies of epidemic poliomyelitis in Sweden, in 1905–6, first pointed out clearly the occurrence of abortive forms of the infection and emphasized strongly their frequency and epidemiological importance. He distinguished several types of abortive cases.

1. With symptoms of general infection.
2. With symptoms indicative of meningitis.
3. With hyperæsthesia and pain.
4. With gastro-intestinal disturbances.

Cases showing symptoms referable to the central nervous system, such as meningitis, hyperæsthesia, disturbances of reflexes, or transitory paresis, are sufficiently distinctive to make a clinical diagnosis

possible. Other cases, however, can be diagnosed only by inference, from their relation to typical cases of poliomyelitis, and are almost certain to be overlooked unless this relation is known. The practicing physician is usually unaware of the relation of his cases to cases occurring in the practice of other physicians. Prompt reporting of all cases to the local health officer will therefore not only help the health officer, but will equally help the practitioner who, by keeping in touch with the health officer and being informed of the relation between cases, may often get a lead on an otherwise impossible diagnosis.

Caverly (12) states that, during the epidemic of poliomyelitis observed by him near Rutland, Vt., in 1894, the prevailing diseases of children were accompanied by unusual nervous symptoms; and similar observations have been made in other epidemics. It would be of great value to obtain, in each focus of epidemic poliomyelitis, careful information concerning diseases of children diagnosed as influenza, neuritis, muscular rheumatism, "summer complaint," etc. Such information can be obtained only by enlisting the hearty cooperation of practicing physicians.

Very frequently, also, abortive cases of poliomyelitis are so slight as not to have been brought to the attention of any physician. The matter, then, of tracing out abortive cases is always one of difficulty, and there is good reason to believe that, except in very limited epidemic foci, such cases have never been traced with satisfactory thoroughness. A house to house canvass of the town seems the only way to accomplish this end satisfactorily.

After tracing up possible abortive cases of poliomyelitis there remains the even greater difficulty of deciding which of these cases may be safely considered as due to this infection. There is the danger on the one hand of too great conservatism and on the other hand of too great enthusiasm for a convenient diagnosis. On the whole, I think it may be safely asserted that the error has generally been on the side of conservatism. In order that the epidemiologist may be able to decide which cases he shall include under the diagnosis of poliomyelitis, it is necessary that he should make a careful clinical study of the disease and that he should, if possible, be provided with a field laboratory sufficient to enable him to make examinations of blood and cerebro-spinal fluid. Examinations of this kind promise to be very helpful to the epidemiologist in the future. Especially in regard to abortive cases it is highly important that the field study be undertaken during the progress of the epidemic or very shortly thereafter, as such mild cases of illness will often have been forgotten alike by physician and family within a few weeks after their occurrence.

It may not be out of place here to call attention to the frequency of abortive, as compared with paralytic, cases in several different localities.

Of the 1,025 cases studied by Wickman (7) in Sweden during 1905–6, 157, or a little over 15 per cent, are classed as of the abortive type. The author states, however, that this does not in his opinion represent the true proportion of such cases. In three circumscribed epidemic foci, offering favorable opportunities for tracing all cases, Wickman found 68 paralytic cases and 62 of the abortive type, approximately 48 per cent of the total. Taking into consideration only those houses

in each of which there occurred more than one case, Wickman states that of 404 cases occurring in 156 houses, 211, or 52 per cent, were of the abortive type.

In Massachusetts (1), in the intensive study of 150 paralytic cases occurring in 142 houses, 49 possible abortive cases were found to have occurred in the same houses, making 26.6 per cent of the total cases.

In a field study in Iowa during the past summer the writer investigated 67 houses in which there had been 74 paralytic cases and 44 possible abortive cases, making a total of 118 cases, of which 37 per cent were possible abortive types. Taking into consideration cases occurring in the same vicinity but not in the same house with paralytic cases, I collected 83 cases which I suspected to be abortive types of poliomyelitis, as compared with 74 frank cases.

Anderson (11), in a summary of 86 cases occurring in Polk County, Nebr., in the summer of 1909, states that 40 per cent of the cases showed no paralysis.

Müller (13) gives an account of an epidemic, evidently poliomyelitis, occurring in the island of Nauru, in Oceania, in January, 1910. Within two weeks 700 of the 2,500 inhabitants of the island were attacked by an acute general infection affecting the nervous system, but of these 700 only about 50 showed paralysis after three months.

The occurrence of abortive cases of poliomyelitis is by this time well established, and while conservatism in diagnosis is to be commended, we can no longer make definite and lasting paralysis the criterion for inclusion of cases under the diagnosis of poliomyelitis. Abortive cases may be considered as probably more important than paralytic cases in the epidemiology of this disease, and no intensive study can now claim to be complete without taking such cases into consideration. These cases, in fact, are deserving of special study, both by the clinician and the epidemiologist.

LOCATION OF CASES.

The plotting of cases upon a map is a helpful and even necessary procedure. The map should be as nearly as possible accurate, and should be on a generous scale. The cases should be plotted on this map with care as to location and with an easily comprehended graphic representation of the date as well as the location of each case. Such a map, showing at a glance the grouping of cases with regard to previous cases, as well as in relation to elevation, drainage, sewage disposal, dusty streets, etc., often shows more at a glance than could be learned from the study of many tabulations.

The map, however, is often misleading unless interpreted in the light of further observations. Epidemiological observations to be reliable must be made by personal canvass of cases. Allowance must be made for a certain amount of error in the information obtained from even the most careful personal canvass. It is the realization of this unavoidable error which leads those who have tried to get accurate information by this means to distrust the accuracy of compilations made from the scattering observation of many different observers.

SYMPTOMATOLOGY.

In the canvass of cases of poliomyelitis it is necessary to go into the symptomatology of each case with more care than is usually required

in the epidemiological study of other infectious diseases. This is necessary because, as already stated, in many cases the diagnosis is doubtful, and clinical study is necessary to give to these cases their proper epidemiological significance. It is desirable also to utilize such an opportunity to collect statistical data as to the symptomatology and ultimate effects of epidemic poliomyelitis.

CONTACT.

In trying to determine the source of infection in each case, while no possible factor should be overlooked, special attention should be paid to determining contact with previous cases, paralytic or abortive. Even when there has been direct contact with a previous case in the acute stage of the disease, it is not always easy to determine this. Contact with unrecognized abortive cases is still more difficult to determine, especially in the case of children, whose playmates are often unknown to the parents. In reckoning the chances for contact account must be taken of neighbors, chance playmates, visitors, and schoolmates; also attendance at schools, Sunday schools and church, public places of business or amusement, railway travel, public drinking cups, etc. Add to this the chances of indirect contact through other members of the family, visitors, servants, tradesmen, etc., and the possible avenues of contact become surprisingly numerous and complex, even for a child kept strictly at home in a small family comparatively isolated. Complicate all this with confusion of dates, failure to remember visits and visitors, and all the other vagaries of the memory, and it is readily seen that even the most careful investigator must needs be very cautious about asserting that there was no chance of contact infection in any given case.

Considering then the difficulties of tracing contact between cases, the tracing of contact is of more epidemiological value than the failure to trace it. This is especially true as regards many of the epidemics which have been reported after very superficial observation.

On the other hand, in interpreting the finding that a certain percentage of cases have been in contact with previous cases, it is necessary to take into consideration numerous factors, such as the probable number of persons exposed to infection and the proportion of these that develop the disease. For instance, in a small community where there had been, say, one case per hundred inhabitants, it would mean very little to find that 20 or 30 per cent of the patients had been in contact with previous cases. This percentage of traceable contacts would mean a great deal more, however, in a larger community where there had been perhaps only one case to each 10,000 inhabitants.

FACTORS OTHER THAN CONTACT.

In the effort to trace out contact between cases one must not lose sight of the numerous other possible factors in the spread of the disease, paying most attention to those factors which seem most probably important, but not forgetting to gather information concerning even the seemingly least important. Factors which must be considered are food and water supply, insects, paralysis of domestic animals, relation to water courses, dust, sewage disposal, general hygienic conditions, previous health, etc.

FOOD AND WATER SUPPLIES.

It is impossible in this space to discuss the relation of all these factors to the spread of poliomyelitis. Moreover, their importance is as yet largely undetermined. Food and water supplies have quite generally been eliminated as probable sources of general infection, although Wickman cites one group of cases apparently infected by their common milk supply.

HYGIENIC CONDITIONS.

Previous health appears to have no appreciable influence in determining infection. The influence of insanitary conditions of life is particularly difficult to determine, as it is usually impossible to make more than a rough estimate of the proportion of people in any community who live under what may be called insanitary conditions.

It would seem that, in general, the disease is more prevalent among those classes of people that live in rather crowded, insanitary surroundings; but the incidence of cases among the lower social strata is not sufficiently disproportionate to justify attaching any great importance to general hygienic conditions as a factor in infection.

INSECT TRANSMISSION.

The probability of insect transmission of the disease is strongly suggested by several epidemiological facts already established. One of the most striking of these facts is the seasonal incidence of epidemics. In this latitude epidemics occur almost without exception in the warm season, from May to November, the season when insects are most prevalent and most active. It is of interest to note in this connection that the epidemics reported from the southern hemisphere have occurred between January and April, a period corresponding seasonally to our late summer and fall months. Another fact which suggests insect transmission is the geographic distribution of epidemics. Generally speaking, epidemic poliomyelitis is a summer disease of cold countries. In Europe, Norway and Sweden, Holland, Germany, and Austria have suffered most; in this country the States which have suffered most are those included in the northeast quadrant.

A further indication of the probability of insect transmission is the distribution of the disease in relation to density of population. Apparently density of population bears no constant relation to the prevalence of epidemic poliomyelitis. Wickman noted this in Sweden in 1905, and statistics for the United States, so far as they are available, confirm this observation. Indeed, it has been noted both in Sweden and in the United States that epidemics of poliomyelitis are most severe in small towns and rural communities, the larger cities as a rule suffering less in proportion to population.

Since the first considerable epidemic in this country occurred in and around New York City in the summer of 1907, and epidemics all over the country have been more common since that time, it is naturally suggested that the disease has spread from New York. Yet if that is the case the spread has been remarkably slow considering the constant communication between New York and other parts of the country, and still more remarkably irregular in its progress. In 1907 the region of greatest prevalence was in and around New York City, extending to Massachusetts. In 1908 there were epidemics in

Massachusetts, Minnesota, Wisconsin, and at least two small outbreaks in Iowa. In 1909 the epidemics reached their height in Massachusetts, Minnesota, and Nebraska. In 1910 the disease has been less prevalent in Massachusetts and Nebraska, but has been epidemic in Iowa, Pennsylvania, District of Columbia, Virginia, Connecticut, and other widely separated States. If the disease has been disseminated from New York along routes of travel, it is hard to understand why it has progressed so irregularly, skipping wide areas of thickly settled country, and why it has spread so slowly, becoming epidemic in the District of Columbia, for example, three years subsequent to the epidemic in New York.

These facts are strongly suggestive of the existence of some as yet unrecognized biologic factor, possibly an insect, the presence of which in a community is necessary or at least favorable to the spread of epidemic poliomyelitis.

Considering, on the other hand, the evidence against insect transmission, the most striking is that presented by laboratory experiments already cited, viz, the low degree of infectiousness of the blood; the apparent dissemination of the virus through the body by the lymph stream rather than the blood; the demonstrated infectiousness of the nasal and buccal secretions; the possibility of infecting animals through the normal mucosa of the respiratory and digestive tracts. Epidemiological studies have failed to give evidence of the prevalence of unusual insects or of common insects in unusual numbers in epidemic foci; they have failed to give any evidence of an extrinsic period of incubation; they have failed to show that infection is confined to places rather than persons; and have, indeed, shown the probability of healthy persons acting as carriers of infection. Any insect to merit consideration as an obligatory factor in the transmission of poliomyelitis must be of almost world-wide distribution and perennial prevalence, for poliomyelitis has occurred in all latitudes from Australia to Canada, and, while epidemics have been confined almost exclusively to the warm months, scattered cases have been reported in the United States in every month of the year. On the whole, the evidence at present available is against the theory of any insect being a necessary or important factor in the spread of the disease; but on this, as on other points, undoubtedly more evidence is needed—another indication of the necessity for field studies.

PARALYSIS OF DOMESTIC ANIMALS.

As regards the relation of paralytic diseases of animals to epidemic poliomyelitis, it has been noted in connection with a number of epidemics that domestic animals, especially chickens, dogs, horses, hogs, cattle, and sheep, were found in the same community to be suffering from paralytic diseases clinically similar to the disease prevailing among human beings. The earliest observations of this kind of which I am aware were recorded by Caverly[12] in his report of an epidemic occurring at Rutland, Vt., in 1894, when he noted paralysis of chickens and dogs. One of these chickens, examined by Dana[14], of New York, showed lesions of the lumbar cord resembling the lesions of acute anterior poliomyelitis.

So far as I have been able to ascertain from an incomplete review of the literature, this is the most suggestive evidence yet presented of a close relation between fowl paralysis and human poliomyelitis.

The pathology of the paralytic diseases of animals has evidently not been sufficiently studied, but the bulk of the pathological evidence now available is against the assumption of a close etiologic relation between such affections and epidemic poliomyelitis. Numerous attempts have been made to inoculate laboratory animals other than monkeys with the virus of human poliomyelitis, the results being uniformly negative except for the inoculations of rabbits, previously referred to.

The reports of paralysis among domestic animals in localities where poliomyelitis is prevalent have certainly been quite striking. Paralysis among domestic animals is, however, quite common and may be due to diverse causes, and it may be that the numerous reports of it from such localities are due more to increased interest in the matter than to any unusual prevalence of paralysis of animals in such localities. The most careful investigation of this point by the Massachusetts state board of health (1) showed that the distribution of paralysis among animals did not correspond to the distribution of human poliomyelitis.

DUST.

The occurrence of epidemic poliomyelitis in the hot, dry, dusty season has given rise to the surmise that dust may be in some way a factor in the spread of the disease. This surmise has been strengthened by the grouping of cases along dusty thoroughfares, observed in several localities, and by the cessation of several epidemics shortly after the dust had been abated by rainfall or sprinkling of streets.

Other observations in support of the causative relation of dust to epidemic poliomyelitis are, the greater incidence of the disease among children at the age when they are likely to crawl and play in the dust, and the greater incidence among males, who are out of doors in the dust, than among females, who are more intimately exposed to infection through contact with sick persons. It has been suggested, in view of the occurrence in horses of a disease resembling poliomyelitis that the infective agent in dust is horse manure. The excessive prevalence of dust has not, however, been found constantly to coincide with the prevalence of poliomyelitis. It is true that the disease is more prevalent in the late summer and fall months; it is also true that dust is generally more prevalent at this season, but the coincidence is not sufficient to establish the relation of cause and effect.

SUMMARY.

Epidemic poliomyelitis must, in the light of present knowledge, be regarded as most probably transmissible by direct contact. Its spread, to be sure, does not exactly follow the routes and the laws which we should expect in the case of a disease transmitted by direct contagion; but it is to be remembered that infection of the human body with any micro-organism is a fairly complex biological phenomenon into which there may enter many factors other than the mere bringing together of the body and the germ.

We must consider, first, that the infecting organism is not an unchanging fixed quantity; not a definite thing like a stable chemical compound, but a far more complex and probably very variable factor—a living organism, reacting to all kinds of external conditions. Realizing the complexity of conditions in the environment of the organism,

together with our inability even to analyze these conditions, much less to appreciate their effect upon an ultramicroscopic body, we should be prepared to find the organism deviating at times from the course which, with our very limited knowledge, we would lay down for it.

Taking up, on the other hand, the factor of susceptibility to the infection of poliomyelitis, we may assume this factor also to be extremely variable. There are some facts which indicate that only a certain proportion—usually a small proportion—of persons exposed to the disease are readily susceptible to infection. In general it has been found that only one, or, at most, a few, of a family have the disease. Assuming that the disease is contagious, the other members certainly have been exposed to infection, and their failure to develop the disease would seem to be due to a lack of susceptibility. Even assuming that the disease is not contagious and that infection is contracted from some other source in the environment, it certainly is probable that in general the members of one family, especially the small children, are likely to be exposed to the same environmental conditions. Whether we regard the disease as contagious or not, the rarity of multiple cases in a family seems best explained by individual variations in susceptibility. The occurrence of abortive cases is also an indication in the same direction.

The conditions constituting susceptibility are, of course, unknown except in a broad, general sense. Statistics indicate that children are more susceptible than adults; that males, especially in later life, are more susceptible than females; the white races more than the negro. The increased incidence of the disease in the summer months, among children, suggests the possible operation of causes similar to those which make diarrhœal diseases especially prevalent among children in hot weather.

NECESSITY OF FURTHER STUDIES.

It has been the object of this paper not to explain the spread of epidemic poliomyelitis, but rather to point out the difficulties in the way of explaining it; to attempt an interpretation of known facts chiefly to show the deficiencies in the facts. If the facts already ascertained seem contradictory, it is because they are incomplete. What is needed to harmonize the apparent contradictions is more facts. Laboratory workers have contributed a generous share of knowledge concerning this disease; clinicians all over the country are studying it; and every health officer should embrace the opportunity to contribute his share of the facts which shall explain the spread of epidemic poliomyelitis. There is little chance of making a brilliant discovery in this work. If such a discovery remains to be made, it will be made by one or at most a very few of the many workers engaged. There is a certainty, however, that every accurate observation, every common-sense fact added to the subject will play its part in solving a problem that has already become very serious and shows no indication of becoming less so.

PROPHYLAXIS.

While a discussion of the prophylaxis of epidemic poliomyelitis is not strictly germane to this paper, a few words on the subject may perhaps not be altogether out of place.

After a careful consideration of the facts of epidemic poliomyelitis as known at present, it seems to me that health authorities are morally bound to put into effect to the best of their ability certain pretty definitely indicated measures for the prevention of the spread of epidemic poliomyelitis—measures similar to those adopted for the control of other diseases commonly accepted as directly contagious. Without attempting to go into detail, these measures may be given as:

1. Isolation of the patient, with isolation of the contacts so far as practicable—certainly to the extent of excluding members of the patient's family from school for at least two weeks. Exclusion of insects and animals from the room.

2. Disinfection of the secretions of the nose and mouth and of the stools and urine. Disinfection of all articles which might have been contaminated by the patient.

3. Fumigation of premises after recovery.

In framing our expectation of results from these measures we must consider several circumstances:

1. The disease is already disseminated over a wide area. Experience with other widespread contagious diseases, such as scarlet fever, for the control of which we have to depend solely on isolation and disinfection, has demonstrated that we can hardly expect to eradicate such a disease by present methods, but that much may be done in the way of limiting its spread.

2. Epidemic poliomyelitis presents unusual difficulties in the recognition of even typical cases in their early stage and of abortive cases in all stages.

3. It will be difficult to estimate the effect of preventive measures, since the disease often fails to spread in communities where conditions seem most favorable for an epidemic.

The hope is certainly justified, however, that energetic preventive measures will result, if not in an actual immediate reduction in the total number of cases as compared with previous years, at least in a reduction of the number that would have occurred without such measures.

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